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4-24-2010

Wireless security proportional to county development

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Wireless security proportional to county development

By

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Thesis submitted in partial fulfillment of the requirements
for the degree of
Master of Science in
Computer Security and Information Assurance

Rochester Institute of Technology

**B. Thomas Golisano College
of
Computing and Information Sciences**

April 24, 2010

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Computer Security and Information Assurance

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I - ***ABSTRACT***

This paper verify the hypothesis “developed counties have a higher wireless security level than undeveloped counties”, this is performed by doing a quantitative study to a group of 50 samples gathered from a war drive database. In further sections of the paper will be explained the importance of wireless security and how companies like RSA have performed studies to determinate the wireless security level of several major cities around the world.

By following the binomial test and median comparison, the reader will understand why in this paper the hypothesis was rejected. All the results indicate that no relation existed between the two variables, but the human behavior can be affected by many factors not only economical. Plenty of variables exist to study human behavior, for further studies others variables like education level can be considered to performed a study.

II - ***INTRODUCTION***

1. Phenomenon of Interest

We can appreciate today how wireless networks have invaded our home, works and recreational environments. A high percentage of the population in an average technologically developed city can state, that in most of the places they frequent, an active wireless networks exist. Another possible statement is that they own one or more wireless networks.

The popularity of this technology has grown because of several properties it poses. In my opinion, the most influent characteristic at the time of considering this technology is the fact of been able to connect several equipments without having any wired infrastructure, which represents a lower installation cost to the interested user. A seconds but not less important is the flexibility that the users obtains in terms of mobility, without any existing wired attaching the user to a location it can move freely, as long as it has a good signal strength to keep the communication channels.

With the accelerated growth in terms of usage of this technology has also come the need of developing better authentication mechanism, to secure the communication channels. Today wireless networks owners use this technology for many security sensitive tasks, like on-line shopping, internet banking, work and file sharing. Several risks can come if any of these tasks is performed in an insecure channel, work emails and conversation could be intercepted by an intruder if a weak or none encryption mechanism exist. This also apply for online shopping and internet banking, an intruder could get your account user name and password used to log in to the bank or favorite online store, where normally a users has personal information.

Because of the importance of security several institutions have dedicated part of their budget to study how wireless security has improved in cities and other geographical entities. Institutions like RSA performs annual surveys to determinate the percentage of secure and unsecure wireless networks in major cities like London, New York and Paris. In their surveys they determinate the amount of users using wireless authentication mechanisms like WEP, WPA and WPA2.

The city with the most unsecured networks was London, with 14% of the 11657 samples taken. Compared to the Dominican Republic, the city of Santo Domingo to be specific, where it appears that at least 5 of 10 networks do not have an encryption mechanism active, the London security level seems far more superior to the one in Santo Domingo. Considerer the 50% of insecure networks in Santo Domingo a shy value, since no study have been made to measure the level of unsecure networks we can only speculate, but the percentage if at least 10% higher by what IT professionals think and by what you see when you perform a quick war drive around an area.

Because of the difference of security between these two cities, the study will analyze the relation between income per capita and wireless security of counties. Cities will not be taken because the Data found to perform the analysis corresponds to Counties in the United States of America, but the result obtained by the analysis can be considered true independently of the geographical entity. In case that a relation exist between this two variables the county with more economical developed cities will have more security than the one with less economical activity.

In case this hypothesis turns to be true, it will be demonstrated that education and access to information have an important role in the fight against unsecure wireless networks.

2. Type Study to be conducted.

The study will be analyzed using the quantitative paradigm, this paradigm consists in explaining or verify phenomenon by using mathematical models. The data used in this type of study is numerical, for example, temperature, income per capita and in our case wireless security percentage.

In order to prove the hypothesis a statistical analysis of the data will be performed, this analysis will be described in detail in the methodology section. We will calculate the median income per capita of the 50 samples, in order to separate them into two groups of counties. Group A will be formed by counties with an income per capita below the median which we will be called undeveloped counties and Group B will have counties with an income per capita above the median which will be called developed counties.

After separating the two groups the median security level of each group will be calculated, in order to determinate if the undeveloped counties have a security level below the developed counties. Also will be calculated the probability of having the X amount of items that satisfy the null hypothesis to determinate the occurrence of our result and determinate if was a product of chance or if in fact the hypothesis is true.

After analyzing the county data, the Dominican Republic position in terms of security and income per capita will be analyzed in order to determinate if the less developed counties or regions in the Dominican Republic have a wireless security level that relates to its income per capita.

3. Describe the theoretical perspective, assumptions and concepts.

In this study wireless networks are separated by two categories, none secure and secure. Secure networks are all the networks with any type of authentication mechanism present in them, as contrast, non secure networks will be all networks without an authentication mechanism present.

The counties will be treated as equal by assuming that the amount of networks obtained by www.wiggle.com are equal, since the purpose of this investigation is to determinate the relation between income per capita and wireless security. The samples will not be pond rate.

The grade of development will be defined by the amount of income per capita of the county, high income per capita will define a well developed city. The reader must understand that the meaning of income per capita which is the amount money corresponding to each individual in a particular county from the total income of the county.

4. Questions and Objectives of the Study

The objective of the study is to determinate if a county with high income per capita has higher wireless security level than counties with less income per capita.

5. Describe the significance of the study.

This study can impact directly the way manufactures use to incentive user to secure their equipment, for example, today we see wizards in modern access point that allow the user to set an authentication mechanism in a few easy steps.

If the hypothesis turns to be true, educational articles could be incorporated in these wizards to achieve a high level of comprehension of the user about the wireless security relevance in today world. By having knowledge of the consequences the users would take more responsible decisions when the time of choosing a secure mechanism for networks comes.

If it turns to be false, new scopes to create consciousness about the importance of wireless security will need to be planed, today efforts have been giving result, the amount of information and the easy access to this information have improved the wireless security but not as fast as the technology has been propagating.

III - REVIEW OF LITERATURE

1. Review

In order to understand the investigation the reader needs to understand what is considered a developed county, as mention before the metric to be used will be income per capita. If we search in any dictionary, we will see that income per capita is defined as the division of the national income of a country, county, city or group divided by the total population of any of the four element or geographic entities. As mentioned before, in our case will be used the income per capita of the county since the samples of wireless networks taken by wiggle are group by county.

Income per capita is commonly used to measure the level of economical development of a particular zone, but several disadvantages exist of using this to measure the wealth of a geographic entity. For example, informal economy is not taken under consideration because the government does not keep track of this type of business and transactions.

An example of this type of economic practice could be a garage sale. In some cases informal economy represent a sizeable portion of the overall economy of the geographic entity. Another disadvantage is that the income per capita does not indicate the income of all citizens of the geographical entity since one could have a higher income than others. [8]

Another topic which the reader needs to be familiar with is wireless networks or 802.11. The 802.11 is the name given by the IEEE (Institute of Electrical and Electronics Engineers) after creating the standard in 1990. The IEEE in 1997 approved the standard witch worked at 2.4GHz with transition rates of 1 and 2 Mbps. At the time was the only standardize technology with that transmission rate in the market.

After the first 802.11 several changes have been made to improve the transmission rate of the networks, now we see the popular 802.11g which can manage a transfer speed of 54Mbits. With the growing popularity of this technology several security challenges came. Because of the nature of wireless networks data could be intercepted by anyone with an antenna. Several mechanism of authentication and encryption of the data were developed to protect the networks and one of them is WEP.

WEP or Wired Equivalent Privacy is a cipher system that was included in the 802.11 standard. It utilizes keys of 64bits or 128bits to encrypt the data which nowadays can be easily cracked. This is why in several years after it released WPA and WPA2 were created. Both have a stronger encryption mechanism than WEP and also can be cracked today, but require certain level of knowledge and computational power that normally conventional users don't poses.

Even though many encryption mechanisms have been created to protect the communication, they are still several equipment that because of their limited computational capabilities and power cannot have a strong encryption mechanism. Sandra Kay Miller in her article "Facing the Challenge of Wireless Security" states " the accelerated growth of wireless networks had made the equipment manufactures incorporate wireless modules in big devices like Routers, Computers, Gaming Consoles and others. This growth is not only seen in this big equipment also in small equipment like cell phones and sensors which are devices with a small power source and low processing power, in addiction implementing robust wireless security to this small devices becomes a challenge because of its characteristics. " [7]

A typical user normally doesn't think about the consequences of letting their Bluetooth active in their mobile device or an open home wireless network. Normally their main concern is that a stranger will get advantage of their internet connection for free ignoring other more important threads [9]

Is good to keep in mind that security, in order to exist, requires a certain level of education among the individuals in the area, this is why this thesis will determinate if a relation between more developed counties with a high income per capita are more secure than the less developed counties.

Because of the amount of diverse uses that are given to wireless networks, several organization have dedicated their resources to study wireless security of geographic entities, one example of this institutions is the RSA. Several surveys about wireless security have been done over the world; for example, the RSA which is the security division of EMC performed surveys in New York, London and Paris.

This survey reveals that cities like New York only had a 3% of home and business wireless networks unsecured. Also reveals that WEP authentication is one of the most popular mechanisms in business networks having a 47% of the business networks samples. On the other hand home networks seem to adventure to more secure authentication mechanisms, 61% prefer WPA and other advance mechanism than WEP. [2]

London on the other hand has an issue with wireless security. 20% of business wireless networks are unsecured, but has a higher percentage of users with advance authentication mechanisms. Instead of WEP which is used by a 32% of the networks, home owners seem to be more conscious of security. Only a 10% of networks are unsecured in the city and 48% use advance authentication mechanisms like WPA and 42% use WEP.[1]

Paris, according to the surveys has the most secured networks as we all know, WEP can be easily compromised today, only a 24% of the overall networks evaluated use WEP, 71% use advance authentications mechanism which is more reliable, and 5% are unsecured. [3].

Overall with the studies made by RSA, we can appreciate the high security level of 3 cities with a high income per capita .To improve wireless security vendors of wireless equipment have worried to provide the latest encryption algorithms in their equipments. Also, considerable changes had been made through the years to wireless configuration wizards and now we see interfaces that ask if you want to setup security in your equipment at the time of initialization. These interfaces are highly helpful since most of the users do not have knowledge of how the technology works and even less how to set it up.

Currently, no studies have been made about the relation of income per capita or economical development of a county with wireless networks security. In theory we could say that counties with higher income per capita have a higher quality of life and better access to technology, which at the same time means more ways to access information which increases the education level of the citizens of the geographical entity.

By understanding the paragraph above, we can say that more economical developed geographic entities should have higher wireless security than the ones with lower economical development.

IV - **METHODS**

1. Tools

The tool used to calculate the statistic is called SPSS. The free trial version offers several options that allow the user to perform fast calculus of the Mean, Standard Deviation and other important statistical data that will be required in this study.

In order to gather the information about the amount of secure and insecure wireless networks in a county, the jigle client application from www.wiggle.net is used to access their war drive database, that provides all the information needed to determinate the wireless security level of the selected counties.

The demographic information of the counties was obtained from the http://quickfacts.census.gov. This useful online tool gives a wide range of information about counties, states and cities in the United States, information like the income per capita, percentage of undergraduate and others.

2. Data Selection Process.

To select the data, an investigation of the income per capita of several counties was done in the website “http://quickfacts.census.gov” which provides a wide range of information like, income per capita, population size, high school graduate percentage, and others of each geographical entity of the United States.

After selecting randomly 50 counties within different ranges of income per capita, information about the amount of insecure and secured networks was gathered from www.wigle.net by using their client application jigle. The data about wireless networks was gathered by active users which upload war drive logs to the wiggle database.

The Dominican Republic data comes from previews worked done by myself, a total of 3 cities were war drive, which are Santo Domingo the capital city of the country, Santiago the second largest city in the country and Moca one of the small cities of the country.

3. Analysis

Table #1 "Global Samples"

NAME	INCOME PER CAPITA	%
Dixie County, Florida	$13,559	57.89%
Bronx County, New York	$13,959	36.77%
Idaho County, Idaho	$14,411	66.67%
Colusa County, California	$14,730	57.14%
Caribou County, Idaho	$15,179	42.08%
Pershing County, Nevada	$16,589	49.39%
Armstrong County, Texas	$17,151	39.39%
Columbia County, Washington	$17,374	29.17%
Butte County, California	$17,517	56.26%
Alachua County, Florida	$18,465	38.89%
Miami-Dade, Florida	$18,497	38.53%
Kent County, Delaware	$18,662	37.80%
Ida County, Iowa	$18,675	11.11%
Madison County, Iowa	$19,357	43.86%
Carson County, Texas	$19,368	27.57%
Hampden County, Massachusetts	$19,541	39.81%
Whatcom County, Washington	$20,025	36.81%
Ellis County, Texas	$20,212	21.40%
Sussex County, Delaware	$20,328	43.14%
Burleigh County, North Dakota	$20,436	44.42%
Franklin County, Massachusetts	$20,672	29.76%
Los Angeles, California	$20,683	25.53%
Bennington County, Vermont	$21,193	31.07%
Calaveras County, California	$21,420	65.33%
Amador County, California	$22,412	55.38%
Worcester County, Massachusetts	$22,983	36.64%
Albany County, New York	$23,345	32.64%
Prince George's County, Maryland	$23,360	49.20%

Storey County, Nevada	$23,642	51.30%
Washoe County, Nevada	$24,277	52.12%
Alpine County, California	$24,431	32.82%
New London County, Connecticut	$24,678	56.38%
Essex County, New Jersey	$24,943	26.66%
Barnstable County, Massachusetts	$25,318	41.04%
Calvert County, Maryland	$25,410	64.36%
Tolland County, Connecticut	$25,474	44.77%
Hartford County, Connecticut	$26,047	37.38%
Burlington County, New Jersey	$26,339	21.27%
Alameda County, California	$26,680	35.61%
Juneau County, Alaska	$26,719	48.18%
Douglas County, Georgia	$27,288	35.31%
Talbot County, Maryland	$28,164	46.27%
Middlesex County, Connecticut	$28,251	46.41%
DC, WASHINGTON	$28,659	30.40%
Contra Costa County, California	$30,615	37.97%
Norfolk County, Massachusetts	$32,484	21.31%
Bergen County, New Jersey	$33,638	29.64%
San Francisco County, California	$34,556	37.91%
Fairfield County, Connecticut	$38,350	25.78%
New York County, New York	$42,922	26.59%

In order to perform the analysis we first need to state the hypothesis that will be tested. As a Null hypothesis or H0 this study will part from the following reasoning. There is a relation between income per capita and the wireless security level of a particular geographic entity. Always, no matter the amount of samples, if we separate the samples in two groups, Group A conformed by items with an income per capita lower than the median and Group B conformed by items with an income per capita higher than the median income per capita. Group A will have all its items with a security level below the median and Group B will have all items with a wireless security level above the median.

This indicates that in any given number of samples, it will always appear a Group B with a higher income per capita and wireless security level than the samples median that represents the 50% of the population. This is why we will consider the probability of taking a developed country with high security from the total population is 50%.

H0: p = 0.5. Developed counties have a higher security level.

The alternate hypothesis, as the opposite of the null hypothesis, indicates that no relation exists between income per capita and wireless security level of a particular geographical entity. In other words the result will be different than the 50/50 relation that conforms the null hypothesis.

This indicates that H1 will be true, if the probability of having an element of the sample higher than the median security level is different from 0.5 or P!=0.5;

H1: p <> 0.5, more developed counties have less security.

In terms of proportion this test will be limited to 50, due the limitations of using wiggle as a source of data. Wiggle receive information from users located in several counties, many of them do not have information, because no one have uploaded any data.

Now we need to define Type I and Type II errors. A Type I error or error of the first kind consist on rejecting the null hypothesis when the analyst have enough knowledge and knows it is true. In other words, it happens when we see in the experiment a result that shows a difference with the null hypothesis when in truth there is actually none. An example of this could be test that shows that a person has a particular disease when he is actually healthy.

Type II errors or error of the second kind, consist on accepting the null hypothesis when the result of the test turn to be false. For example, a test to a person with a particular disease that turned to be false when he is actually having health issues.

By defining Type I and Type II error we cover all the possible result in the experiment. In the following table it is shown how the result are distributed.

Table #2 “Type Errors”

		With a Disease	With no Disease
EXPERIMENT	Healthty	Type I (he actually is sick)	OK
	Not Healthy	OK	Type II (he actually is not sick)

To separate the groups first we have to calculate the median value of the income per capita and security level, by using the excel function “average” we obtain the following values. It can be done by hand also, by sorting from lower to higher the income per capita. In case there is an odd amount of entries taking the value of the entry that separates the sample in two equal parts is taken as the median value, if a pair amount of entries exist then the two values that separates the sample in two groups are summarized and divided by two.

For example, in 1,2,3,4,5 we see there is an odd amount of entries because of that we shoce as the median 3.

Another example, in 1,2,3,4,5,6 we see there is a pair number of entries, we execute (3+4)/2 to obtain the median which is 3.5.

Remember the median value is the one located in the exact middle of the range of results obtained in a numerical sample.

Table #3 "Median of the Sample"

Income Per capita Median	Security median
$22,698	38.25%

Now with the income per capita we can separate the items in two groups in GROUP A the counties with an income per capita bellow the median which we will consider underdeveloped. Group B has the more developed counties. They all have an income per capita higher than the median.

Table #4 "GROUP A"

NAME	INCOME PER CAPITA	Security %
Dixie County, Florida	$13,559	57.89%
Bronx County, New York	$13,959	36.77%
Idaho County, Idaho	$14,411	66.67%
Colusa County, California	$14,730	57.14%
Caribou County, Idaho	$15,179	42.08%
Pershing County, Nevada	$16,589	49.39%
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Ellis County, Texas	$20,212	21.40%
Sussex County, Delaware	$20,328	43.14%
Burleigh County, North Dakota	$20,436	44.42%
Franklin County, Massachusetts	$20,672	29.76%
Los Angeles, California	$20,683	25.53%
Bennington County, Vermont	$21,193	31.07%
Calaveras County, California	$21,420	65.33%
Amador County, California	$22,412	55.38%

Table #5 "GROUP B"

Name	Income per Capita	Security %
Worcester County, Massachusetts	$22,983	36.64%
Albany County, New York	$23,345	32.64%
Prince George's County, Maryland	$23,360	49.20%
Storey County, Nevada	$23,642	51.30%
Washoe County, Nevada	$24,277	52.12%
Alpine County, California	$24,431	32.82%
New London County, Connecticut	$24,678	56.38%
Essex County, New Jersey	$24,943	26.66%
Barnstable County, Massachusetts	$25,318	41.04%
Calvert County, Maryland	$25,410	64.36%
Tolland County, Connecticut	$25,474	44.77%
Hartford County, Connecticut	$26,047	37.38%
Burlington County, New Jersey	$26,339	21.27%
Alameda County, California	$26,680	35.61%
Juneau County, Alaska	$26,719	48.18%
Douglas County, Georgia	$27,288	35.31%
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Contra Costa County, California	$30,615	37.97%
Norfolk County, Massachusetts	$32,484	21.31%
Bergen County, New Jersey	$33,638	29.64%
San Francisco County, California	$34,556	37.91%

Fairfield County, Connecticut	$38,350	25.78%
New York County, New York	$42,922	26.59%

Now the next step consist in verifying how many items of group A have a lower security percentage than the wireless security median which is 38.25% and how many in group B have a wireless security percentage above the median. The following table shows the results.

Table #6 "Group A elements satisfying null hypothesis"

Less than median security % (satisfy null Ho)	Higher than median security % (Do not satisfy Ho)
10	15

We can see that the percentage of items with wireless security level less than the median is 40% and the remaining is the percentage of items that did not resulted to be true and the median security level of this group A is 41.01%

Table #7 "Group B elements satisfying null hypothesis"

Higher than median security %	Less than security %
15	10

We can see that 60% of the group B items had a wireless security level higher than the median wireless security value and the remaining 40% were the items that resulted to be false and the median of this group is 38.72%

Table #8 "Binomial Test Results"

Probability of success on a single trial	0.5
Number of trials	50
Number of successes (x)	25
Binomial Probability: P(X = 25)	0.112275

The value of the variable ”number of success” is 25, meaning that from the entire sample only 25 elements satisfies the null hypothesis. In Group A we can see 10 elements that have a wireless security level below the median value. These 10 elements, plus the 15 elements that satisfy the null hypothesis in Group B, form a total of 25 elements that satisfy the null hypothesis.

Because of the nature of the test, the Probability of success on a single trial is 0.5. We have only two possible results in our test and the elements can only satisfy or not the null hypothesis, in other words the result can be true or false.

The Binomial value represents the probability of having X elements between the samples that support the null hypothesis. In this case is $p = 0.1122$ or 11.22% which means that there is practically no chance of getting a sample with more than a 50% of success. By knowing this we can determinate that no relation between income per capita and wireless security level exist.

The probability of selecting a geographical entity that satisfy the null hypothesis is a 50%, in order to consider true the null hypothesis a higher value of P would be require and a success rate of at least 85% of the sample.

By making another binomial test with the following data:

Success rate = 45

Trials = 50

Probability of success = 0.5

We will see that the chance of having more successful items in the samples becomes even smaller, the P value in this case turns to be 9*10^-9 which is practically impossible to obtain. Another factor that rejects the null hypothesis is that the median of the less developed counties is higher than the median of the more developed counties.

Now we will proceed to analyze the Dominican Republic data:

Table #9 “Dominican Republic war drive information”

Region/County	Unsecure Networks	Secure Networks
Santo Domingo	26.68%	73.32%
Santiago	30.97%	69.03%
Moca	26.21%	73.79%

Since in the Dominican Republic the income per capital is calculated by the sector that generates the income and not the geographical entity we will use the Dominican Republic income per capita and the wireless security average from the samples as the representation of the country. The income per capita of Dominican Republic is 4815.6$ USD and the average security level is 72.05%.

V – RESULTS

The first analysis we will performed is by comparing the two median values of Group A and Group B. By performing the analysis described in the methodology we obtained the following results.

Table #10 "Mean Values"

	Total Sample	Group A	Group B
Median	38.25%	41.01%	38.72%

If we part from the idea that the null hypothesis is true and there is a relation between income per capita and wireless security level we can state the following. The median value of Group A should have a similar distance or difference from the total sample median and the value of the first item of Group A. Also we can state that there should be a similar distance or difference between the median of Group B and the medians values of the total sample and the last item value of Group B.

This can be explained with the following example:

If we performed 10 test to this equation f(x) = x*2 with number from 1 to 10 we will get the following result.

Table #11 “F(x) Results”

X	F(X)
1	2
2	4
3	6
4	8
5	10
6	12
7	14
8	16
9	18
10	20

We can appreciate that the median value of F(X) is 11 because of Median = (12+10)/2, also we can see that the median values of the items below the total median is 6 and the median of the items above is 16. We can see that the distance of the first group median from the total median and the lower value of F(x) is of 4, the same happens to the median of the group above the total median and the higher value of F(x) in the sample. This occurs because a linear relation exists between them.

In our experiment we don’t see this type of behavior, as we can see in table #11, the distance between the total Median and Group B median is of 0.47 and the difference between Group B median and the item with higher security level in Group B is of 25.64.

On the other hand group A had a similar behavior the distance from the total median to Group A median is of 2.76 and the difference between the lower security item and Group A median is of 29.9. From this test we can be sure that their does not exist a relation between income per capita and wireless security, another interesting behavior we see is that the median of Group A which are the undeveloped counties is greater than the median of Group B or developed counties. If any type of relation that sustained the null hypothesis would have existed this wouldn’t be happening.

Table #12 "Distance between Median"

	Lower Security	Higher Security	Group A	Group B
Lower Security	-	53.25	29.9	27.61
Higher Security	53.25	-	23.35	25.64
Group A	29.9	23.35	-	2.29
Group B	27.61	25.64	2.29	-
Total Median	27.14	26.11	2.76	0.47

Since by analyzing the median from the samples we did not obtained any evidence of the null hypothesis been true, we will proceed to analyze the result from the binomial test which is the probability of obtaining the result we had from a given number of samples. We see that the probability of obtaining this result was of 11.22%. This probability gets even lower if is calculated with a success rate of 90%, we had a probability of less than 1% this practically a direct rejection to the null hypothesis because of the lack of chance of getting this result.

Now by taking the Dominican Republic Data, we can see that the country is part of Group A because of the overall the counties in this group have a income per capita higher than the 4815.6$ USD of the Dominican Republic, in fact the hole sample of the united states has a higher income per capita. This means that the overall security of the United States must be higher than the Dominican Republic.

By calculating the average security level and income per capita of the sample we can determinate the following

- USA income per capita = 23,180USD
- USA Wireless Security level = 39.86%

By getting these values we see that Dominican Republic has a much lower income per capita than the USA, but has a higher wireless security level, in fact all the samples taken in Dominican Republic had a higher wireless security level than any of the samples taken in the USA. This might happened because of the nature of the USA war drive data, this data could be representing a particular zone since several users upload data of the same area, and on the other hand, the data gathered of the Dominican Republic was done by a single user in different areas, the samples are not repeated.

This result reveals the lack of relation of only income per capita and wireless security, since the income per capita of a county its only one of the factors that can alters a group of individual’s behavior. We can say that more variables need to be involved in this investigation.

Variables like the education level, rhythm of life and age of the population could be included, a younger population can be more curious about new technologies and have more information about the risks of having unsecure wireless networks. On the other hand a population with an agitated rhythm of life could be more careless than a population with a more calm rhythm.

Others studies can be done involving how comfortable are access points interfaces, in order to measure how many consider they interfaces comfortable, user friends but at the same time have their network without any security.

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VII – APENDIX

A. Income per capita Dominican Republic By Year

Producto Interno Bruto Percápita
1991-2009

Período	Población (Miles)	PIB Corriente (Millones de RD$)	PIB Corriente (Percápita RD$)	PIB Referencia 1991 (Millones RD$)	PIB Referencia 1991 (Percápita RD$)	PIB Corriente (Millones de US$)	PIB Corriente (Percápita US$)
1991	6,968	123,426.0	17,713.6	123,426.0	17,713.6	9,575.6	1,374.3
1992	7,129	144,063.3	20,208.7	136,402.0	19,134.0	11,392.7	1,598.1
1993	7,293	162,205.1	22,240.0	146,253.8	20,052.9	12,882.5	1,766.3
1994	7,425	182,840.3	24,626.4	149,622.4	20,152.4	14,213.5	1,914.4
1995	7,558	211,024.6	27,920.3	157,842.1	20,883.8	15,857.3	2,098.1
1996	7,694	233,833.3	30,391.5	169,098.4	21,977.9	17,411.5	2,263.0
1997	7,832	274,423.9	35,037.0	182,633.5	23,317.7	19,401.4	2,477.1
1998	7,973	311,282.8	39,040.8	195,437.2	24,511.5	20,724.0	2,599.2
1999	8,117	343,745.3	42,350.5	208,561.5	25,695.4	21,575.8	2,658.2
2000	8,263	388,301.9	46,994.8	220,359.0	26,669.3	23,799.3	2,880.3
2001	8,411	415,520.9	49,400.3	224,345.8	26,672.0	24,561.0	2,920.0
2002	8,563	463,624.3	54,145.6	237,331.4	27,717.4	24,985.6	2,918.0
2003	8,717	617,988.9	70,898.7	236,730.1	27,158.8	20,432.1	2,344.1
2004*	8,873	909,036.8	102,447.1	239,835.9	27,029.2	22,608.7	2,548.0
2005*	9,033	1,020,002.0	112,922.3	262,051.3	29,011.2	33,774.7	3,739.1
2006*	9,195	1,189,801.9	129,393.9	290,015.2	31,539.9	35,897.2	3,903.9
2007*	9,361	1,364,210.3	145,740.7	314,592.8	33,608.4	41,228.1	4,404.5
2008*	9,529	1,576,162.8	165,409.8	331,126.8	34,750.0	45,717.6	4,797.8
2009*	9,700	1,678,762.6	173,068.0	342,564.1	35,315.8	46,711.6	4,815.6

*Cifras preliminares

(http://www.bancentral.gov.do/estadisticas_economicas/sector_real/pib.xls)

B. Growth Rates Dominican Republic by Year

Tasas de Crecimiento (%)

Período	Población (Miles)	PIB Corriente (Millones de RD$)	PIB Corriente (Percápita RD$)	PIB Referencia 1991 (Millones RD$)	PIB Referencia 1991 (Percápita RD$)	PIB Corriente (Millones de US$)	PIB Corriente (Percápita US$)
1992	2.3	16.7	14.1	10.5	8.0	19.0	16.3
1993	2.3	12.6	10.1	7.2	4.8	13.1	10.5
1994	1.8	12.7	10.7	2.3	0.5	10.3	8.4
1995	1.8	15.4	13.4	5.5	3.6	11.6	9.6
1996	1.8	10.8	8.9	7.1	5.2	9.8	7.9
1997	1.8	17.4	15.3	8.0	6.1	11.4	9.5
1998	1.8	13.4	11.4	7.0	5.1	6.8	4.9
1999	1.8	10.4	8.5	6.7	4.8	4.1	2.3
2000	1.8	13.0	11.0	5.7	3.8	10.3	8.4
2001	1.8	7.0	5.1	1.8	0.0	3.2	1.4
2002	1.8	11.6	9.6	5.8	3.9	1.7	(0.1)
2003	1.8	33.3	30.9	(0.3)	(2.0)	(18.2)	(19.7)
2004*	1.8	47.1	44.5	1.3	(0.5)	10.7	8.7
2005*	1.8	12.2	10.2	9.3	7.3	49.4	46.7
2006*	1.8	16.6	14.6	10.7	8.7	6.3	4.4
2007*	1.8	14.7	12.6	8.5	6.6	14.9	12.8
2008*	1.8	15.5	13.5	5.3	3.4	10.9	8.9
2009*	1.8	6.5	4.6	3.5	1.6	2.2	0.4

*Cifras preliminares

(http://www.bancentral.gov.do/estadisticas_economicas/sector_real/pib.xls)

C. Binomial Test

Conditions of Use: Use the binomial test when you have dichotomous data - that is, when each individual in the sample is classified in one of two categories (e.g. category A and category B) and you want to know if the proportion of individuals falling in each category differs from chance or from some pre-specified probabilities of falling into those categories.

Assumptions: The normal approximation for the Binomial test assumes that the proportion of the time that individuals are expected to fall into category A (symbolized by "p") multiplied by the total number of individuals in category A and B combined (symbolized by "n") is greater than 10 (i.e. $pn>10$) and that the proportion of the time that individuals are expected to fall into category B (symbolized by "q") multiplied by the total number of individuals is greater than 10 (i.e. $qn>10$). If either of these conditions are not met then the normal approximation for the binomial test should not be used (use the Binomial distribution instead).

Example: In a recent study examining colour preferences in infants, 30 babies were offered a choice between a red rattle and a green rattle. Twenty-five of the 30 selected the red rattle. Do these data provide evidence for a significant colour preference? Test at the 0.01 level of significance.

Step 1. State the hypotheses, and specify alpha. The null hypothesis states that the proportion of babies preferring red rattles is not different from what is expected for a population where there is no preference for rattle colour. In symbols,

$$H_0 : p = p(red) = 0.5 \text{ and } q = p(green) = 0.5$$

The alternative hypothesis is that the proportions for the colour preferences are different from what is expected for these chance population proportions.

$H_1 : p \neq 0.5 \, (\text{and} \, q \neq 0.5)$

We will set $\alpha = 0.01$.

<u>Step 2</u>. Locate the critical region. Because *pn* and *qn* are both greater than 10, we can use the normal approximation to the binomial distribution. With $\alpha = 0.01$, the critical region is defined as any z-score value greater than +2.3263 or less than -2.3263.

<u>Step 3</u>. Calculate the test statistic. In the sample 25 out of 30 babies prefer the red rattle, so the sample proportion is.